ring was rather difficult, but on December 30 it was easily seen and its granular structure detected.

THE "ANNUAIRE" OF THE BUREAU DES LONGITUDES, 1912.—This year's issue of the "Annuaire" contains the usual astronomical information, ephemerides, and tables, and deals with chemistry and physics similarly. It also contains the complete list of minor planets, for 714 of which it gives the orbital elements. Among the "notes" there appear an interesting *résumé* of solar physics by M. Deslandres, a long discussion on the various calendars, an article by M. Bigourdan on seismology, a brief description of the physical constitution of the moon by M. Puiseux, and a discussion of the mean temperature in various parts of France by M. Bigourdan. All the times in this "Annuaire" are given in accordance with the new law of March last. The price of the "Annuaire" is 1.50 francs net.

THE RADIAL VELOCITIES AND SPECTRAL TYPES OF STARS.

ALTHOUGH the determination of radial velocities is, as a practical proposition, a development of comparatively recent years, the data already secured by the several observatories doing line-of-sight work promises to be of inestimable value in the study of cosmological problems. It is no longer merely a question of "approach" or "recede"—a far greater vista has been opened up as the work has proceeded. Combined with the researches of Kapteyn, Eddington, Dyson, and others on the streaming tendencies disclosed by the discussion of "proper motions," it promises a rich mine of as yet undisclosed facts concerning the evolution of enormous sidereal systems.

A glance through Prof. Campbell's second catalogue of spectroscopic binaries[1] tells of much work already accomplished, and the discussion discloses how much there is still to be done.

One outstanding result of this discussion of more than 300 binary systems, so far as it applied to the comparative few for which the periods of revolution and other orbital elements have been determined, was the fact that the motions of the stars are intimately related to the spectral types which may be taken as indices of stellar ages. Briefly, it appears that the older a binary system becomes the greater becomes the eccentricity of the orbit and the longer grows the period of revolution.

The existence of the relation between radial velocities and stellar types was also brought out in a later paper[2] dealing with some peculiarities in the motions of the stars, where the following table was given, the spectral types being given under the Harvard designations:—

Spectral types	No. of stars	Average radial velocities
O and B	141	8·99 km.
A	133	9·94 ,,
F	159	13·90 ,,
G and K	529	15·15 ,,
M	72	16·55 ,,

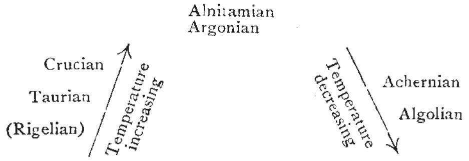
In the general discussion it was found that the B-type ("helium") stars called for special treatment, and Prof. Campbell discussed the motions of the brighter stars of this type in a further paper.[3]

The main conclusion to which we wish to direct attention here is that "An error, of obscure source, causes the radial velocities of Class B stars to be observed too great by a quantity, K, amounting to several kilometres. For stars of Class B–B_5 the value of this error is approximately $K = +4{\cdot}7$ km. per second. The value obtained for Class B–B_9 stars is $+4{\cdot}1$ km. It is therefore probable that K is less than $+4$ km. for stars of Class B_8–B_9."

The result was based on the consideration of 225 Class B stars, K being an assumed, unavoidable, but systematic error inherent to the observed velocities, and disclosed in calculating from these the velocity of the solar system in space. This systematic difference, peculiar to the B-type stars, has led to some very interesting and important suggestions as to the characteristics of the stars themselves; Prof. Campbell makes several tentative suggestions as to its source. Of these, we would direct attention to that in which it is suggested that in these stars the absorption takes place in the lower layers of the atmospheres, and therefore under greater pressure, thus modifying the effective wave-length and producing the error when the measures of wave-length are compared with terrestrial standards. Another suggestion points out that the helium lines frequently used in the measures are double, with the red component, in the laboratory, much the fainter. If the conditions in the star increase the relative intensity of these red components, the wave-length of the centre of gravity of the whole line would be shifted, and the observed difference be thus produced.

A most interesting contribution to the discussion of the motions of this type of star is published by Dr. Ludendorff[4] in the form of some remarks on the classification of helium stars. He takes from Campbell's list of 224 stars all those which have an absolute radial velocity, V_2, $\geqq 8{\cdot}0$ km., and shows that there is a distinct differentiation of their velocities if they are arranged according to Lockyer's classification[5] of the helium stars.

As is generally known, this classification is unique in that it aims at arranging the classes of stars in an evolutional order, difference in the chemical characteristics, accompanying differences in age and temperature, being the criterion. It also essentially takes into account the idea that stars probably increase before decreasing in temperature, and on these lines arranges the helium stars at the top of the temperature curve thus:—



In the Lockyer classification the Rigelian class is not given as essentially a helium class, although helium is mentioned as one of the prominent elements; for this latter reason Dr. Ludendorff includes it in his discussion.

Of the sixty-three stars selected from Campbell's list, he finds eighteen classified in the South Kensington catalogue, and tabulates them as follows, the velocities being given in round numbers:—

Ascending branch of Curve			Descending branch of Curve		
Star	Type	V_2	Star	Type	V_2
		km.			km.
ζ Persei	Crucian	+ 9	π Andromedæ	Algolian	+ 8
η Orionis	,,	+14	ν ,,	Achernian	−24
β Canis Maj.	,,	+10	19 Tauri	Algolian	−10
o² ,,	Taurian	+25	γ Corvi	,,	−13
η ,,	,,	+17	ι Aquilæ	Achernian	−14
δ Crucis	Crucian	+13	ε Delphini	,,	−10
χ Centauri	,,	+ 8	α ,,	Algolian	−10
ε Lupi	,,	+12	o Andromedæ	Achernian	−10
υ Scorpii	,,	+21			
67 Ophiuchi	Rigelian	+10			

From this table evolves the striking fact that, without exception, those stars placed by Lockyer on the ascending arm of the temperature curve all have + velocities, and, with one exception, those on the descending side have − absolute radial velocities. It would appear extremely unlikely that this remarkable division is due to chance; but Dr. Ludendorff seeks further evidence by taking from Campbell's catalogue all (seventy-one) those stars classified at South Kensington as helium stars—including the Rigelian class—and arranges them as follows, giving the mean absolute radial velocities $V_2{}^0$ of each class:—

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[1] Lick Observatory Bulletins, No. 181. [2] *Ibid.*, No. 196. [3] *Ibid.*, No. 195.

[4] *Astronomische Nachrichten*, No. 4547, vol. cxc., p. 193.

[5] Catalogue of 470 of the Brighter Stars Classified according to their Chemistry.

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α. Ascending arm of Lockyer's curve.

1. Rigelian stars	$V_2^0=+2\cdot3$ km.	3 stars
2. Taurian ,,	$=+8\cdot8$,,	4 ,,
3. Crucian ,,	$=+3\cdot7$,,	38 ,,

β. Maximum of Lockyer's curve.

1. Alnitamian stars	$V_2^0=-0\cdot4$ km.	5 stars
2. Argonian ,,	—	0 ,,

γ. Descending arm of Lockyer's curve.

1. Achernian stars	$V_2^0=-5\cdot4$ km.	11 stars
2. Algolian ,,	$=-3\cdot7$,,	10 ,,

Grouping them further, and taking general means for each of the groups α, β, and γ, we get:—

α. $V_2^0=+4\cdot1$ km.	45 stars	mean error	$\pm1\cdot03$ km.
β. $V_2^0=-0\cdot4$,,	5 ,,	,,	$\pm1\cdot29$,,
γ. $V_2^0=-4\cdot6$,,	21 ,,	,,	$\pm1\cdot72$,,

It is obvious that the β group is so small, and its mean error so much greater than the mean value of the velocities, that it is negligible, and Dr. Ludendorff considers only the α and γ groups; the difference between these is $+8\cdot7$ km., with a mean error of $\pm2\cdot0$ km.

Further analysis shows that, of the forty-five stars in group α, thirty-one have V_2 positive, with a maximum of +25 km., and fourteen negative, with a maximum negative value −7 km., while the mean of the + values is $+7\cdot2$, and that of the negative values $-2\cdot8$.

Analysing similarly the γ group, the mean $-V_2$ is 8·8 km., and the mean $+V_2$ is $+3\cdot9$ km., so there can remain no reasonable doubt as to the reality of the connection between + values and "ascending" stars and − values and "descending" stars.

Taking these same seventy-one stars and arranging them under the Harvard equivalents of the Lockyer classes is rather a hazardous proceeding on account of the generical differences of the two classifications with their consequent overlappings; but Dr. Ludendorff has done it systematically, and finds that the mean velocity difference between the analogues of the α and γ groups employed above is $+3\cdot6$ km., with a probable error of $\pm2\cdot41$ km. It is evident that the systematic difference so obvious in the previous tables is somewhat obscured, and it becomes more so when the whole of Campbell's 224 stars are arranged under the Harvard equivalents of the Lockyer classes. Dr. Ludendorff therefore concludes the comparisons with the statement that when one arranges the helium stars of Campbell's catalogue under the Lockyer classification, there appears in the mean values of the absolute radial velocities of the several classes a distinct systematic difference. When one arranges the stars under the Harvard, or the Miss Maury, classifications, this systematic difference is not so clear as under the Lockyer arrangement.

Arising out of the question as to the reality of the observed difference, several suggestions as to its origin are made. The question of systematic error in the actual measuring is dismissed, and the evidence of streaming, disclosed by arranging the stars in four R.A. groups, is very small.

Dr. Ludendorff concludes with the suggestion that the wave-lengths in the spectra of helium stars vary with the condition of the star, and that this variation of condition may also be a function of Lockyer's arrangement of the stellar classes. Further, he makes the important suggestion that, as the Lockyer classification discloses this systematic difference, while the Harvard classifications do not show it so clearly, in the future discussion of a definite classification of the stars the classification which discloses this difference, possibly dependent upon spectral evolution, should receive most careful consideration. The elements of the spectral change, as shown in this discussion of the helium stars, are already incorporated in the classification, which by further natural development, and maybe slight modifications, may be made still more to portray the development of a star as it grows older.

WILLIAM E. ROLSTON.

EDUCATIONAL CONFERENCES CONSIDERED IN RELATION TO SCIENCE IN PUBLIC SCHOOLS.[1]

II.

Laboratory Work in Schools and in Examinations.

IN our previous article we gave an account of those discussions at the annual meeting of the Public School Science Masters' Association which dealt with the sequence of studies. The remaining discussions were concerned with the position of qualitative analysis and the relation between laboratory work in schools and the practical examinations of public examining bodies. Dr. E. B. Ludlam (Clifton) found the position of the teacher difficult, as he thought that modern methods were better than those in which qualitative analysis had figured so largely, but was obliged by the scholarship examinations and those for the higher certificate to retain too much of the older methods. At the same time, he found that boys were stimulated by exercises in the identification of substances, a process which enlarged a boy's chemical experience and gave scope to his individuality. He therefore advocated a study of "comparative chemistry," with early attention to metals and the periodic classification; in connection therewith, the boys should work out their own methods of identification. From the discussion on examinations, opened by Mr. G. F. Daniell, it appeared that there was a desire for more alternative questions, *i.e.* more options, in the practical tests, and Mr. H. Richardson suggested a number of useful variants from the ordinary type of question. In practical chemistry, the use of the blow-pipe and some work with unknown substances should be retained; but there had been too much refinement of analytical work, both qualitative and volumetric. Problems, accompanied by fairly full working instructions, would bring the examination work more into line with the work in the school laboratory. The opener, and several subsequent speakers, advocated closer relations between teachers and examiners, and agreed that it was important that the examiner should be present during the laboratory examination.

Mathematical Teaching.

It is usually unprofitable to deal with papers on mathematical subjects by means of short abstracts. We therefore give the programme of the meeting of the Mathematical Association, and attempt to review the present position in the light of the discussions.

The president's address, by Prof. E. W. Hobson, appeared in NATURE of January 18. Mr. C. Godfrey gave some account of the work of the International Commission on Mathematical Teaching. Mr. G. St. L. Carson read a paper on some unrealised possibilities in mathematical education, and there was a discussion on the introduction of the calculus, in which Mr. C. V. Durell, Mr. A. W. Siddons, Dr. T. P. Nunn, and others took part.

Broadly stated, the papers threw light upon (1) the democratisation of mathematics; (2) the relation between the instrumental and the philosophical elements in mathematical teaching. Prof. Hobson's address makes clear what we wish to convey by (1), and we observed that the idea influenced most of the speakers. Prof. Perry and the Board of Education use the term "practical mathematics" in the sense of vocational mathematics, and Prof. Hobson had apparently the same idea in his references to "practical life." Where the president spoke of the "practical side" being overdeveloped he had in view laboratory exercises. By "instrumental" mathematics we mean the method of teaching which uses the utilitarian motive in order to lead the pupil to mathematical concepts. We put it that Prof. Hobson recognises the democratisation of mathematics as a welcome fact, believes that this justifies some, but not exclusive, use of the instrumental method, and lays stress on the necessity for combining with the latter considerable philosophical and deductive training. Mr. Godfrey told us that Italy had, more than any other country, continued to demand a philosophical treatment of geometry from young beginners, employing methods more rigorous than those of Euclid. Germany, on the other hand, had gone farther than any other nation in develop-

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[1] Continued from p. 394.

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